

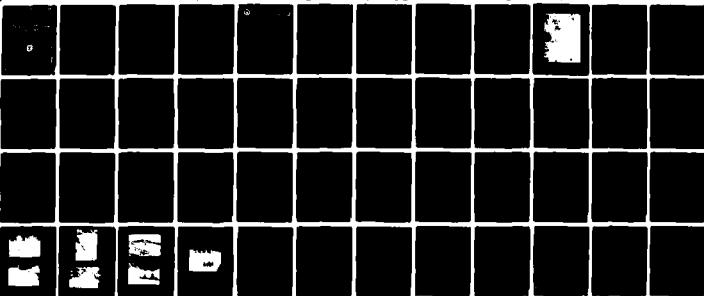
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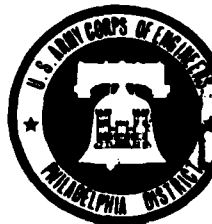
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RARITAN RIVER BASIN  
AMBROSE BROOK, MIDDLESEX COUNTY  
NEW JERSEY

# CREIGHTON LAKE DAM NJ 00787

PHASE 1 INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM



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DEPARTMENT OF THE ARMY DTIC

Philadelphia District  
Corps of Engineers  
Philadelphia, Pennsylvania

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(16)  
National Dam Safety Program. Creighton Lake Dam (NJ 00787), Raritan River Basin, Ambrose Brook, Middlesex County, New Jersey. Phase I Inspection Report.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.			

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Honorable Brendan T. Byrne  
Governor of New Jersey  
Trenton, New Jersey 08621

31 JUL 1981

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Creighton Lake Dam in Middlesex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Creighton Lake Dam, initially listed as a high hazard potential structure but reduced to a low hazard potential structure as a result of this inspection, is judged to be in poor overall condition but the spillway is considered adequate. The low hazard potential classification means that in the event of failure of the dam, no loss of life and only minimal economic loss is expected. For the same reasons no further studies are recommended. However, to assure the continued functioning of the dam and its impoundment, the following remedial actions could be undertaken by the owner:

- a. Investigate the cause of and monitor the seepage at the downstream toe of the dam to the left of the left spillway wingwall.
- b. Repair the erosion of the upstream slope of the dam and provide erosion protection for the upstream slope of the dam.
- c. Repair the low level outlet pipe.
- d. Repair of major erosion of the mortared rip-rap surface near the center of the dam which extends from the crest to the downstream toe of the dam.
- e. Remove the trees and brush and their roots from the entire embankment.
- f. Repair the erosion of the spillway surface.

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Honorable Brendan T. Byrne


- g. Control trespassing on the dam.
- h. Remove trees and brush for a distance of 25 feet or to the property line, whichever is lesser downstream, from the toe of the dam.
- i. Re-establish and maintain grassy vegetation on the upstream crest of the dam after repair of the eroded areas on the dam.
- j. Clear trees and brush on either side of the spillway discharge channel for some distance from the spillway toe.
- k. Repair the cracking in the spillway abutment walls.
- l. Develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congresswoman Fenwick of the Fifth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,



ROGER L. BALDWIN  
Lieutenant Colonel, Corps of Engineers  
Commander and District Engineer

1 Incl  
As stated

Copies furnished:

Mr. Dirk C. Hofman, P.E., Deputy Director  
Division of Water Resources  
N.J. Dept. of Environmental Protection  
P.O. Box CN029  
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief  
Bureau of Flood Plain Regulation  
Division of Water Resources  
N.J. Dept. of Environmental Protection  
P.O. Box CN029  
Trenton, NJ 08625

CREIGHTON LAKE DAM (NJ00787)


CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 20 April 1981 by Anderson-Nichols & Co. Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Creighton Lake Dam, initially listed as a high hazard potential structure but reduced to a low hazard potential structure as a result of this inspection, is judged to be in poor overall condition but the spillway is considered adequate. The low hazard potential classification means that in the event of failure of the dam, no loss of life and only minimal economic loss is expected. For the same reasons no further studies are recommended. However, to assure the continued functioning of the dam and its impoundment, the following remedial actions could be undertaken by the owner:

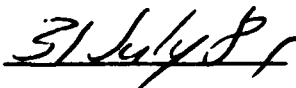
- a. Investigate the cause of and monitor the seepage at the downstream toe of the dam to the left of the left spillway wingwall.
- b. Repair the erosion of the upstream slope of the dam and provide erosion protection for the upstream slope of the dam.
- c. Repair the low level outlet pipe.
- d. Repair of major erosion of the mortared rip-rap surface near the center of the dam which extends from the crest to the downstream toe of the dam.
- e. Remove the trees and brush and their roots from the entire embankment.
- f. Repair the erosion of the spillway surface.
- g. Control trespassing on the dam.
- h. Remove trees and brush for a distance of 25 feet or to the property line, whichever is lesser downstream, from the toe of the dam.
- i. Re-establish and maintain grassy vegetation on the upstream crest of the dam after repair of the eroded areas on the dam.
- j. Clear trees and brush on either side of the spillway discharge channel for some distance from the spillway toe.
- k. Repair the cracking in the spillway abutment walls.
- l. Develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

APPROVED:

  
ROGER L. BALDWIN

Lieutenant Colonel, Corps of Engineers  
Commander and District Engineer

DATE:





PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

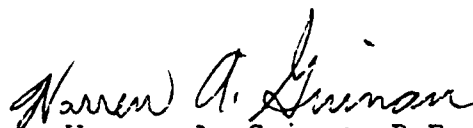
Name of Dam:	Creighton Lake
Identification No.:	Fed. ID No. NJ00787
State Located:	New Jersey
County Located:	Middlesex
Stream:	Ambrose Brook
River Basin:	Raritan
Date of Inspection:	April 20, 1981

ASSESSMENT OF GENERAL CONDITIONS

Creighton Lake Dam is a 45-year old structure, consisting of a low, ogee spillway and an earthfilled embankment with a concrete core wall. The dam is in poor overall condition. It is small in size and should be downgraded to low hazard from its initial classification of high hazard. Brush and trees are growing on both upstream and downstream slopes and along the upstream crest. Trespassing has denuded both upstream and downstream slopes of grassy vegetation. Much of the downstream slope to the left (south) of the spillway has been covered with a mortared rip-rap that has been seriously eroded over the portion that covers the 48-inch corrugated metal pipe low-level outlet. This pipe has corroded through near the outlet end at the crown. Settlement of the pipe outlet has occurred and the end is partially filled with sediment. Erosion has exposed the tree roots along the outlet retreat channel that parallels the toe of the dam for 30 feet before this channel empties into Ambrose Brook. The head gate was not visible but the gate stem and other metal parts were corroded. The spillway will pass the 50-year test flood and is considered adequate.

Creighton Lake Dam does not pose a potential hazard to loss of life and only minimal property damage could occur if it should be breached; the downstream channel and bridge openings are capable of passing up to 50-year test flood. However, should the owner wish to maintain the integrity of the embankment he should retain the services of a professional engineer, qualified in the design and construction of dams to accomplish the following as specified. Starting soon: investigate the cause of the seepage at the downstream toe of the dam to the left of the left spillway wingwall; design or specify repairs for the erosion of the upstream slope of the dam and design and specify erosion protection for the upstream slope of the dam; and design and specify repairs to the low level outlet pipe. In the near future: repair of major erosion of the mortared rip-rap surface near the center of the dam which extends from the crest to the downstream toe of the dam; remove the trees and brush and their roots from the entire embankment; and design and specify repairs for the erosion of the spillway surface.

It is further recommended that the owner accomplish the following tasks as part of operational and maintenance procedures. Beginning soon: start a program to monitor the seepage along the toe of the downstream slope and control trespassing on the dam. In the near future: develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam. In the future: remove trees and brush for a distance of 25 feet downstream from the toe of the dam or to the property line whichever is less; re-establish and maintain grassy vegetation on the upstream crest of the dam after repair of eroded areas on the dam; clear trees and brush on either side of the spillway discharge channel for some distance from the spillway toe; and repair the cracking in the spillway abutment walls.



Warren A. Guinan, P.E.  
Project Manager  
New Jersey No. 16348



OVERVIEW PHOTO  
CREIGHTON LAKE DAM

20 April 1981

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CREIGHTON LAKE DAM FED ID NO. NJ00787

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## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonable possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY INSPECTION PROGRAM  
CREIGHTON LAKE DAM  
FED ID NO. #NJ00787

SECTION 1  
PROJECT INFORMATION

1.1 General

a. Authority. Authority to perform the Phase I Safety Inspection of Creighton Lake Dam was received from the State of New Jersey, Department of Environmental Protection, Division of Water Resources by letter dated 12 December 1980 under Basic Contract No. FPM-39 and Contract No. A01093 dated 10 October, 1979. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367 and by agreement between the State and the U.S. Army Engineer District, Philadelphia. The inspection discussed herein was performed by Anderson-Nichols & Company, Inc.

b. Purpose: The purpose of the Phase I Investigation is to develop an assessment of the general conditions with respect to the safety of Creighton Lake Dam and appurtenances. Conclusions are based upon available data and visual inspection. The results of this study are used to determine any need for emergency measures and to conclude if additional studies, investigations, and analyses are necessary and warranted.

1.2 Project Description

a. Description of Dam and Appurtenances. Creighton Lake Dam is a 200-foot long earth embankment with an 8-inch wide concrete core wall on the crest and a 37.5-foot long concrete ogee spillway. The hydraulic and structural heights are both 10.8 feet. The crest of the dam is bare of vegetation. The downstream slope below the core wall, has a mortared rip-rap surface. The upstream slope is partially brush covered. A 48-inch diameter gated corrugated metal outlet pipe is located approximately 30 feet to the left (south) of the left spillway abutment.

b. Location. The dam is located in Middlesex Borough, Middlesex County, New Jersey on Ambrose Brook. The dam is at 40° 34.0' north latitude and 74° 31.0' west longitude on the Bound Brook Quandrangle. A location map has been included as Figure 1. The dam can be reached by taking Route 18 North (Exit 5 off the New Jersey Turnpike) to Route 28-Bound Brook Road. Turn right and the dam is approximately 1/2 mile down the road on the right side.

c. Size Classification. Creighton Lake Dam is classified as being small in size on the basis of storage at the dam crest of 250 acre-feet, which is less than 1000 acre-feet but more than 50 acre-feet, and on the basis of its structural height of 10.8 feet, which is less than 40 feet, in accordance with criteria given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. Ambrose Brook flows under Raritan Avenue about 950 feet below the dam. About 3,250 feet downstream of the dam, Ambrose joins Green Brook just above Lincoln Avenue Bridge, which is 1,000 feet above Green Brook's confluence with the Raritan River. The channel and the bridge at both Raritan and Lincoln Avenues have sufficient capacity to pass up to the 50-year test flood. No inhabited houses, other structures, or property are endangered in the downstream area, either from a flood up to the magnitude of the 50-year test flood or in case the dam should be breached. Because there would be no significant property damage or loss of life, Creighton Lake Dam should be classified as low hazard. Its spillway will pass a 50-year test flood and is considered adequate.

e. Ownership. The dam is owned by the Borough of Middlesex, 1200 Mountain Avenue, Middlesex, New Jersey. Information may be obtained from the Middlesex Borough Municipal Office at the above address.

f. Purpose. Creighton Lake Dam was built for recreational purposes.

g. Design and Construction History. The original 1936 design plan of the dam (#274) was available in the NJDEP files and was used for the plan and profile in this report.

h. Normal Operational Procedure. No operational procedures exist for the dam.

i. Site Geology. No site specific geologic information (such as borings) was available at the time the dam was inspected. Information derived from the Geologic Map of New Jersey (Kummel and Lewis, 1912) and the Glacial Drift of New Jersey (Salisbury, Kummel, Peet and Whitson, 1902) indicates soils within the immediate site consist of stratified drift which may include sand and gravel plains, deltas, eskers, kames, terraces or other deposits associated with or resulting from Wisconsin glaciation.

The design plan shows that the dam was built on shale. However, shale outcrops were not observed during the dam inspection. The previously mentioned map indicates that bedrock in this area consists of soft red shales and sandstones of Triassic age.

### 1.3 Pertinent Data

#### a. Drainage Area

13.9 square miles

#### b. Discharge at Damsite (cfs)

Maximum flood at damsite - unknown; dam was overtopped in 1971 and 1973 primarily caused by backwater from the Raritan River and Green Brook.

Total ungated spillway capacity at maximum pool elevation 32.8 (at top of dam) - 1518 cfs

#### c. Elevation (ft. above NGVD)

Top of dam - 32.8

Design surcharge (50-year peak inflow) - 32.6

Recreation pool (at time of inspection) - 28.0

Spillway crest - 28.0

Streambed at centerline of spillway - 22.0

Maximum tailwater (estimated) 26.5

#### d. Reservoir (feet)

Length of maximum pool - 3000 (estimated)

Spillway crest - 1400

#### e. Storage (acre-feet)

Spillway crest - 32

Design surcharge (50-year peak inflow) - 220

Top of dam - 250

#### f. Reservoir Surface (acres)

Top of dam - 40 (estimated)

Spillway crest - 6.4



g. Dam

Type - earthfill with concrete core wall

Length - 200 feet

Height - 10.8 feet (hydraulic)

- 10.8 feet (structural)

Top width - 10.5 feet

Side slopes - upstream 2H:1V, downstream 2H:1V

Zoning - not shown on design plan

Impervious core - 8-inch concrete core wall

Cutoff - core wall set into shale bedrock on design plan

Grout curtain - not shown on design plan

h. Spillway

Type - Concrete ogee

Length of weir - 37.5 feet

Crest elevation - 28.0' NGVD

Low level outlet - 48-inch corrugated metal pipe

U/S Channel - Creighton Lake

D/S Channel - Ambrose Brook

## SECTION 2 ENGINEERING DATA

### 2.1 Design

A copy of the original design plans and specifications for the spillway, dam, low-level outlet and core wall dated September 1936 were recovered from NJDEP files. The design plans consist of five sheets. The plans show (1) spillway details (2) low level outlet details, (3) general layout and location of dam, and (4) and (5) plan and sections of the downstream spillway channel.

### 2.2 Construction

Recorded data on file with NJDEP revealed that the dam was constructed over a period of approximately one year from 1936-1937. The plans include some description of the construction materials, however no written specifications were retrieved.

### 2.3 Operation

No written operational data were disclosed.

### 2.4 Evaluation

a. Availability. A search of the New Jersey Department of Environmental Protection files revealed a substantial amount of information. All available information was retrieved.

b. Adequacy. The information retrieved concerning the design and construction of the dam is satisfactory.

### SECTION 3 VISUAL INSPECTION

#### 3.1 Findings

a. Dam. Trees and brush are growing on the embankment to the right of the spillway and on the upstream slope to the left of the spillway. One 20-inch diameter tree is growing near the toe of the downstream slope adjacent to the left spillway training wall. The roots of this tree extended back underneath the adjacent mortared rip-rap surface. Extensive erosion and sloughing of the upstream slope has occurred at and above the waterline caused by wave action and pedestrian traffic.

The dam has an 8-inch wide concrete core wall which is exposed along the crest of the dam. The core wall has some spalling and a few through wall cracks were observed. The crest is bare of vegetation upstream of the core wall. The mortared rip-rap surface covers most of the downstream slope of the dam. A 15-foot wide section of the mortared rip-rap surface, extending from the crest to the downstream toe, has been eroded, exposing the underlying embankment surface near the center of the dam. An erosion channel up to 17 inches deep below the adjacent mortared rip-rap surface has developed near the left side of the erosion feature. Seepage was observed at the base of the vertical stone-masonry wall which is located at the toe of the slope adjacent to the left spillway wingwall. The flow contained orange-colored flocs with no evidence of suspended solids.

#### b. Appurtenant Structures

1. Concrete Core Wall. Some spalling of the top of the 8-inch concrete core wall was observed. The core wall has a few through wall cracks--all less than 1/8-inch wide.

2. Concrete Weir & Abutments. The spillway weir is surface eroded to approximately 1-inch maximum depth exposing the coarse aggregate. No indication of cracking or movement was observed. The mortared stone masonry abutments exhibit some minor cracking in the mortared joints.

3. Outlet Works. The low-level gate on the upstream face was not visible. The gate lifting framework is deformed and badly rusted. No operating mechanism was observed. The downstream end of the outlet pipe was plugged with debris and the pipe is badly corroded. Substantial settlement was observed approximately 6 feet in from the downstream end. Approximately 2 inches of settlement was observed at the downstream end. (The Middlesex Borough Park supervisor reported that the pipe is presently inoperable.)

c. Reservoir Area. The watershed above the lake is gently sloping and has been extensively developed with homes. The slopes on the shore of the lake contain numerous trees and appear stable. No evidence of significant sedimentation was observed.

d. Downstream Channel. Considerable erosion has occurred on the right and left banks of the channel immediately downstream of the spillway for a distance of approximately 200 feet. Trees are growing on the banks of the channel downstream of the dam. One large tree is leaning at a 45° angle towards the channel.

## SECTION 4 OPERATIONAL PROCEDURES

### 4.1 Procedures

No formal operating procedures were revealed.

### 4.2 Maintenance of Dam

No formal maintenance procedures for the dam were found.

### 4.3 Maintenance of Operating Facilities

No formal maintenance procedures for the operating facilities were discovered.

### 4.4 Warning System

No description of any warning system was found.

### 4.5 Evaluation of Operational Adequacy

Because of the lack of operation and maintenance procedures, the remedial measures described in Section 7.2 should be implemented as described.

## SECTION 5 HYDROLOGIC/HYDRAULIC

### 5.1 Evaluation of Features

a. Design Data. Because no original hydrologic design data were revealed, an evaluation of such data could not be performed.

b. Experience Data. Creighton Lake Dam was overtopped in 1971 and 1973; the primary cause being backwater from the Raritan River and Green Brook.

c. Visual Inspection. The spillway for Creighton Lake Dam consists of a 37.5 foot long concrete ogee weir. No visual evidence was found of damage to the structure caused by overtopping. At the time of inspection, approximately 0.1 foot of water was flowing over the spillway crest. Erosion of the surface concrete on the spillway face has exposed the stone aggregate up to one inch in depth.

d. Creighton Lake Dam Overtopping Potential. The hydraulic/hydrologic evaluation for the dam is based on a selected Spillway Design Flood (SDF) equal to the 50-year flood in accordance with the range of test floods given in the evaluation guidelines, for dams classified as low hazard and small in size. The 50-year flood discharge was determined by Stephen J. Stankowski's method as outlined in "Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization", Special Report #38, 1974. Hydrologic computations are given in Appendix 3. The 50-year discharge for the subject watershed is 1469 cfs. The spillway can pass the 50-year flood without overtopping the dam embankment and is considered adequate.

e. Drawdown Capability. If the low-level outlet currently in place is fully operable and free of siltation, it is estimated that the pond can be drained in approximately 3-1/2 hours, assuming no significant inflow. This time period is considered adequate for draining the reservoir in an emergency situation.

## SECTION 6 STRUCTURAL STABILITY

### 6.1 Evaluation of Structural Stability

a. Visual Observations. The seepage at the downstream toe of the dam to the left of the left spillway wingwall is indicative of seepage through and under the dam which, if not properly controlled, could lead to failure of the dam by piping or sloughing of the downstream slope underneath the mortared rip-rap surface. Serious erosion in the exposed area on the downstream slope where the mortared rip-rap is missing could result in slope instability of the embankment downstream from the corewall. Trees growing on the upstream and downstream slopes may cause seepage and erosion problems if the trees blow over and pull out their roots, or if a tree dies or is cut and its roots rot.

6.2 Design and Construction Data. No design or construction data pertinent to the structural stability of the dam are available.

6.3 Operating Records. No operating records pertinent to the structural stability of the dam were available.

### 6.4 Post-Construction Changes

No record of post-construction changes was available.

6.5 Seismic Stability - This dam is in Seismic Zone 1. According to the Recommended Guidelines, dams located in Seismic Zone 1 "may be assumed to present no hazard from earthquake, provided static stability conditions are satisfactory and conventional safety margins exist". None of the visual observations made during the inspection are indicative of unstable slopes. However, because no data are available concerning the engineering properties of the embankment and foundation materials for this dam, it is not possible to make an engineering evaluation of the stability of the slopes or the factor of safety under static conditions.

SECTION 7  
ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. Creighton Lake Dam is 45 years old and is in poor condition.

b. Adequacy of Information. The information available is such that the assessment of the dam must be based primarily on the results of the visual inspection.

c. Urgency. Because the dam poses no hazard to life and negligible hazard to property there is little urgency to implement the recommendations in Sections 7.2 based on safety considerations. Should the owner wish to maintain the dam embankment the recommendations should be implemented as prescribed.

d. Necessity for Additional Data/Evaluation. The information available from the visual inspection is adequate to identify the potential problems which are listed in 7.2.a. below. These problems require the attention of a professional engineer qualified in the design and construction of dams who will have to make additional engineering studies to design or specify remedial measures. If left unattended, the problems could lead to failure of the dam. Because the dam is of low hazard no further hydrologic studies are considered necessary.

7.2 Recommendation/Remedial Measures

a. Recommendations. The owner should retain a professional engineer qualified in the design and construction of dams to accomplish the following in the specified time frame.

Starting soon:

1. Investigate the cause of the seepage at the downstream toe of the dam to the left of the left spillway wingwall.
2. Design and specify repairs for the erosion of the upstream slope of the dam and design and specify erosion protection for the upstream slope of the dam.
3. Design and specify repairs to the low level outlet pipe and gate.



In the near future:

1. Repair of major erosion of the mortared rip-rap surface near the center of the dam which extends from the crest to the downstream toe of the dam.
2. Remove the trees and brush and their roots from the entire embankment.
3. Design and specify repairs for the erosion of the spillway surface.

b. Operating and Maintenance Procedures

The owner should accomplish the following soon:

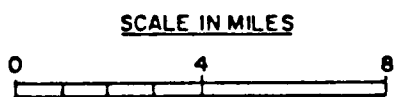
1. Start a program to monitor the seepage along the toe of the downstream slope.
2. Control trespassing on the dam.

The owner should accomplish the following in the near future:

Develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

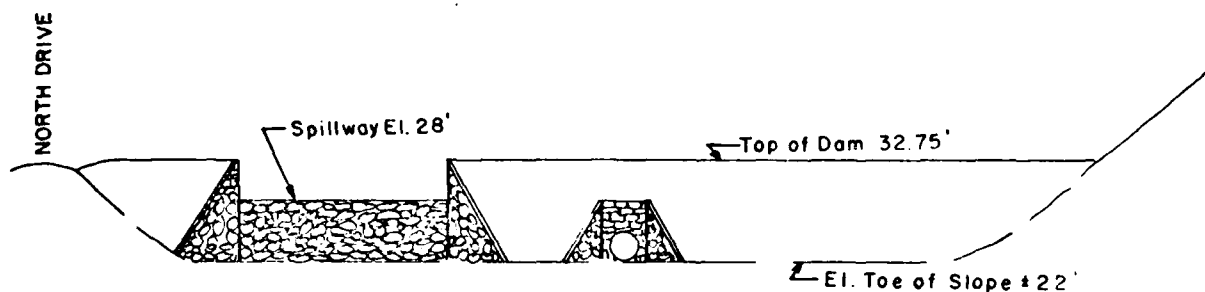
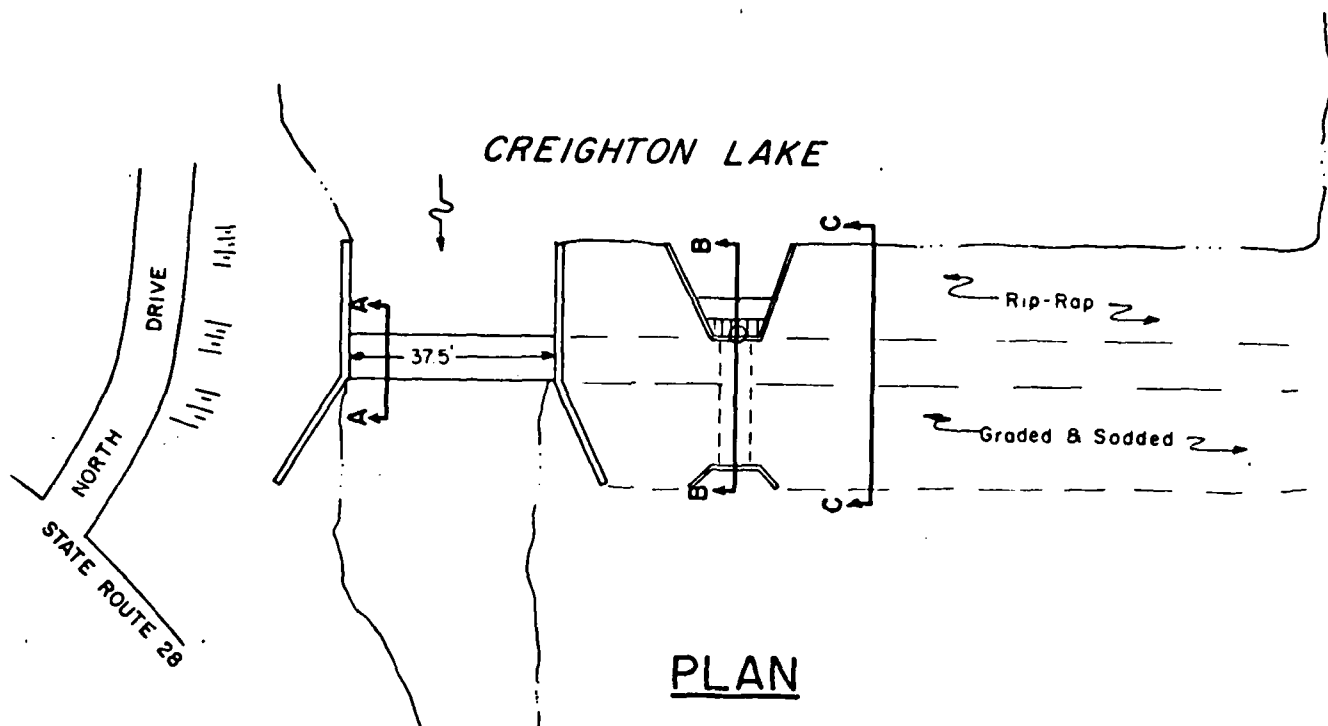
The owner should accomplish the following in the future:

1. Remove trees and brush for a distance of 25 feet or to the property line, whichever is lesser, downstream from the toe of the dam.
2. Re-establish and maintain grassy vegetation on the upstream crest of the dam after repair of eroded areas on the dam.
3. Clear trees and brush on either side of the spillway discharge channel for some distance from the spillway toe.
4. Repair the cracking in the spillway abutment walls.



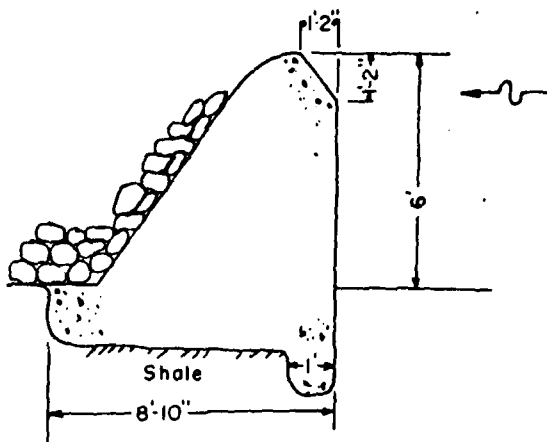
MAP BASED ON STATE OF NEW JERSEY  
OFFICIAL MAP & GUIDE.

Anderson-Nichols & Co., Inc.		U.S. ARMY ENGINEER DIST. PHILADELPHIA	
BOSTON		CORPS OF ENGINEERS	
MASSACHUSETTS		PHILADELPHIA, PA.	
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS			
CREIGHTON LAKE DAM			
LOCATION MAP			
AMBROSE BROOK		NEW JERSEY	
		SCALE: 1" = 4 Miles Approx.	
		DATE: JUNE 1941	
		FIGURE	

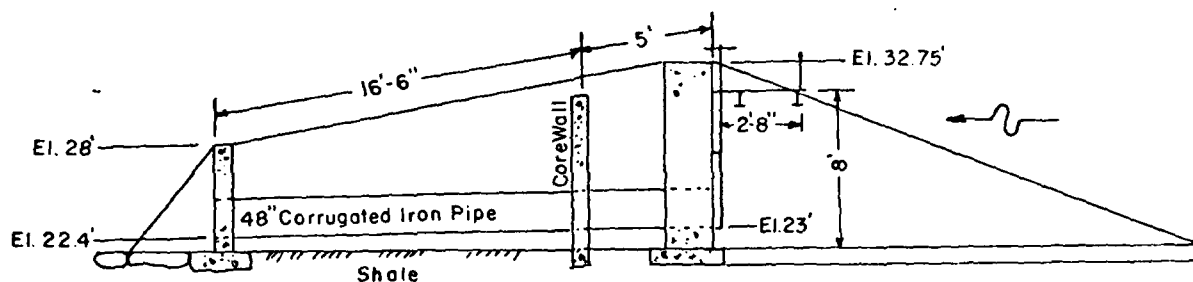


## ELEVATION

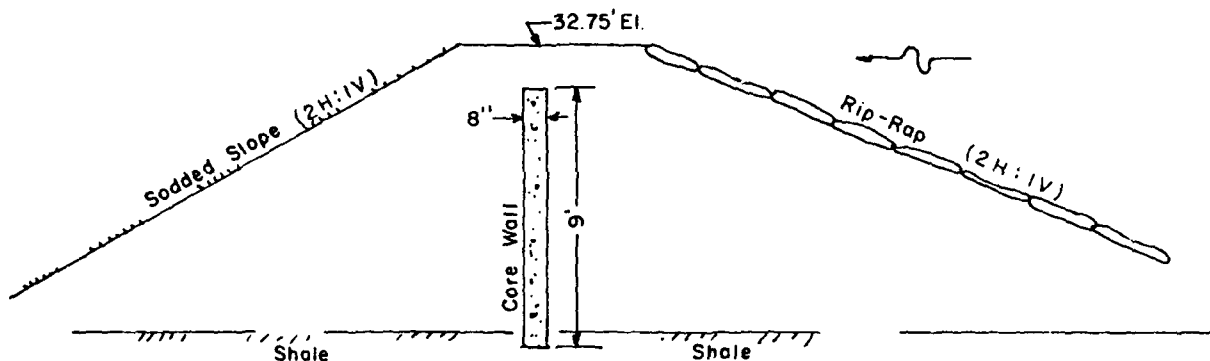
Anderson-Nichols & Co., Inc.		U.S. ARMY ENGINEER DIST PHILADELPHIA	
BOSTON		CORPS OF ENGINEERS	
MASSACHUSETTS		PHILADELPHIA, PA	
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS			
CREIGHTON LAKE DAM			
AMBROSE BROOK		NEW JERSEY	
		SCALE NOT TO SCALE	
		DATE JUN 1981	
		FIGURE 2	



**SECTION A-A**



**SECTION B-B**



**SECTION C-C (Typical)**

Anderson-Nichols & Co., Inc.		U.S. ARMY ENGINEER DIST PHILADELPHIA	
BOSTON		CORPS OF ENGINEERS	
MASSACHUSETTS		PHILADELPHIA, PA	
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS			
CREIGHTON LAKE DAM			
CROSS-SECTIONS			
AMBROSE BROOK		NEW JERSEY	
		SCALE NOT TO SCALE	
		DATE JUNE 1981	
		FIGURE 3	

APPENDIX 1

CHECK LIST

VISUAL INSPECTION

CREIGHTON LAKE DAM

Check List  
Visual Inspection  
Phase 1

Name Dam Creighton Lake Dam County Middlesex State NJ (00787) Coordinators NUDEP  
 Date(s) Inspection 2/18/81 4/20/81 Weather Sunny Sunny Temperature 70° 45°  
 Pool Elevation at Time of Inspection 28.1' NGVD Tailwater at Time of Inspection 21.6' NGVD

Inspection Personnel:

<u>W. Guinan</u>	<u>J. Stone</u>
<u>S. Gilman</u>	
<u>R. Murdock</u>	

R. Murdock Recorder

No owner representative was present at the inspection.

UNGATED SPILLWAY  
OGEE Concrete

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONCRETE WEIR	Surface is eroded - 1-in - exposing the coarse aggregate. Stone masonry abutments - Good condition - Some minor cracking.	Repair eroded concrete. Repair cracks in masonry.
---------------	---	--

APPROACH CHANNEL	Wide and unobstructed.	
------------------	------------------------	--

DISCHARGE CHANNEL	Wide - little debris. One large tree overhanging channel on right bank. Other large trees present on left bank.	Cut trees and brush 25 ft. on either side of channel for a distance of 100 ft. downstream of dam or to the property line, whichever is less.
-------------------	---	--

BRIDGE AND PIERS OVER SPILLWAY	None	
--------------------------------	------	--

EMBANKMENT (with Concrete Core Wall)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Bare ground and erosion of both upstream and downstream slopes to the right and left of the spillway.	Repair erosion and provide adequate erosion protection.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Good	
RIPRAP FAILURES	No riprap evident on either the left or right upstream embankment slopes. Trees growing on the slopes. Large area of gunite protection has been eroded on the downstream slope to the left of spillway channel.	Remove trees and provide adequate erosion protection on upstream slope. Repair section of gunite slope protection which has been eroded.



EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
RAILINGS	None observed.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Erosion evident at the junction with the spillway structure (See also "Sloughing or Erosion..." above.)	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	None observed.	
DRAINS	None observed.	

# OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	See below.	
INTAKE STRUCTURE	Concrete headwall and training walls are surface eroded. No evidence of cracking or other movement.	
OUTLET PIPE	36-in CMP - Badly rusted and settled. Conduit pipe has a substantial negative slope (tilted backward). U/S end - full of debris.	Replace or repair conduit.
OUTLET CHANNEL	See "Ungated Spillway - Discharge Channel."	
EMERGENCY GATE	Operating mechanism missing. Top of frame work is bent. All of frame work is rusted.	Restore gate and operating mechanism to operating order.

# RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gently to moderately sloping. Some wooded sections. Many houses present near shoreline.	
SEDIMENTATION	No evidence of significant sedimentation observed.	

# DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Considerable erosion on right and left banks immediately downstream of the spillway for about 200 ft. Trees are growing on the banks of the channel downstream of the dam.	Cut trees and brush 25 feet on either side of channel for a distance of 100 feet downstream of the dam or to the property line, whichever is the lesser.
SLOPES	Gently sloping banks with some trees and brush.	
APPROXIMATE NO. OF HOMES AND POPULATION	Five houses are located high above the left (south) bank between the dam and Raritan Ave. with an estimated population of 15.	

CHECK LIST  
ENGINEERING DATA  
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
------	---------

PLAN OF DAM  
Original design plans and specifications dated September 1936 are available at NJDEP, Prospect Street, Trenton, N.J. 08625. Used for plan and profile in report-Figures 2&3.

REGIONAL VICINITY MAP  
Prepared for this report.

CONSTRUCTION HISTORY  
Recorded data on file with NJDEP revealed that the dam was constructed over a period of approximately one year from 1936-1937. The plans include some description of the construction materials, however no written specifications were retrieved. See "PLAN OF DAM" above.

TYPICAL SECTIONS OF DAM  
Plans filed September 1936 were used for this report and are available from NJDEP files. See "PLAN OF DAM" above.

HYDROLOGIC/HYDRAULIC DATA  
None found.

OUTLETS - PLAN  
Available information is in the NJDEP files. See "PLAN OF DAM" above.  
- DETAILS Same as above.  
- CONSTRAINTS None found  
- DISCHARGE RATINGS None found

RAINFALL/RESERVOIR RECORDS  
None found

ITEM	REMARKS
DESIGN REPORTS	None found
GEOLOGY REPORTS	None found
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None found
19	
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None found
POST-CONSTRUCTION SURVEYS OF DAM	None found
BORROW SOURCES	Unknown

# REMARKS

ITEM

MONITORING SYSTEMS

None

MODIFICATIONS

None

HIGH POOL RECORDS

None

POST CONSTRUCTION ENGINEERING  
STUDIES AND REPORTS

None

PRIOR ACCIDENTS OR FAILURE OF DAM  
DESCRIPTION  
REPORTS

None

MAINTENANCE  
OPERATION  
RECORDS

None

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Prepared for this report from available plans. See "PLAN OF DAM" on page 1-8.
DETAILS	None.
OPERATING EQUIPMENT PLANS & DETAILS	1 inoperable gate valve. Plan available from NJDEP files. See TYPICAL SECTIONS OF DAMS on page 1-8.



CHECK LIST  
HYDROLOGIC AND HYDRAULIC DATA  
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 13.9 square miles, gentle slope,  
pastures, suburban.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 28' NGVD (32 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY) Not applicable

ELEVATION MAXIMUM TEST FLOOD POOL: 32.6' NGVD

ELEVATION TOP DAM: 32.8' NGVD (250 acre-feet)

SPILLWAY CREST: free overflow concrete spillway

a. Elevation 28.0' NGVD

b. Type Ogee

c. Width 3 feet

d. Length 37.5 feet

e. Location Spillover Right center of dam

f. Number and Type of Gates None

OUTLET WORKS: One 48-inch pipe with upstream sluice gate

a. Type Corrugated metal pipe

b. Location 30 feet left (south) of spillway

c. Entrance Invert 23.0' NGVD

d. Exit Invert 22.4' NGVD

HYDROMETEOROLOGICAL GAGES: None

MAXIMUM NON-DAMAGING DISCHARGE: 1518 cfs

APPENDIX 2

PHOTOGRAPHS

CREIGHTON LAKE DAM



February 16, 1981

View of ogee spillway from right (north) side d/s of dam.



February 16, 1981

View looking along axis from right (north) side.



February 18, 1981

View looking along axis from left (south) abutment.



April 20, 1981

View of downstream face near left spillway training wall.



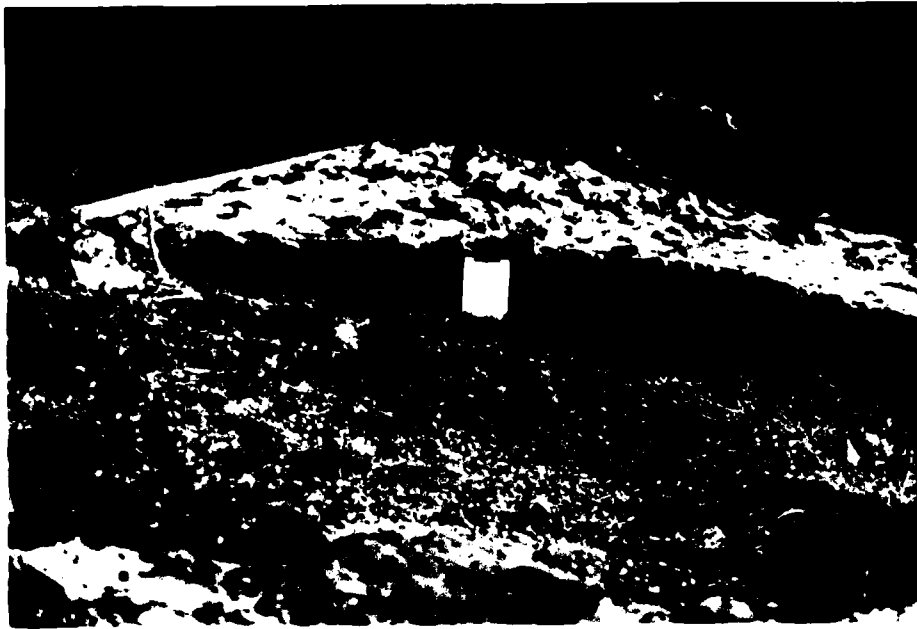
February 18, 1981

View of gate mechanism controlling low-level pipe from left wingwall d/s.



February 18, 1981

View of debris in low-level outlet pipe.



View of escarpment adjacent to mortared masonry riprap -  
17 inches high.

April 20, 1981



View looking u/s at reservoir from crest of dam.

April 20, 1981



February 18, 1981

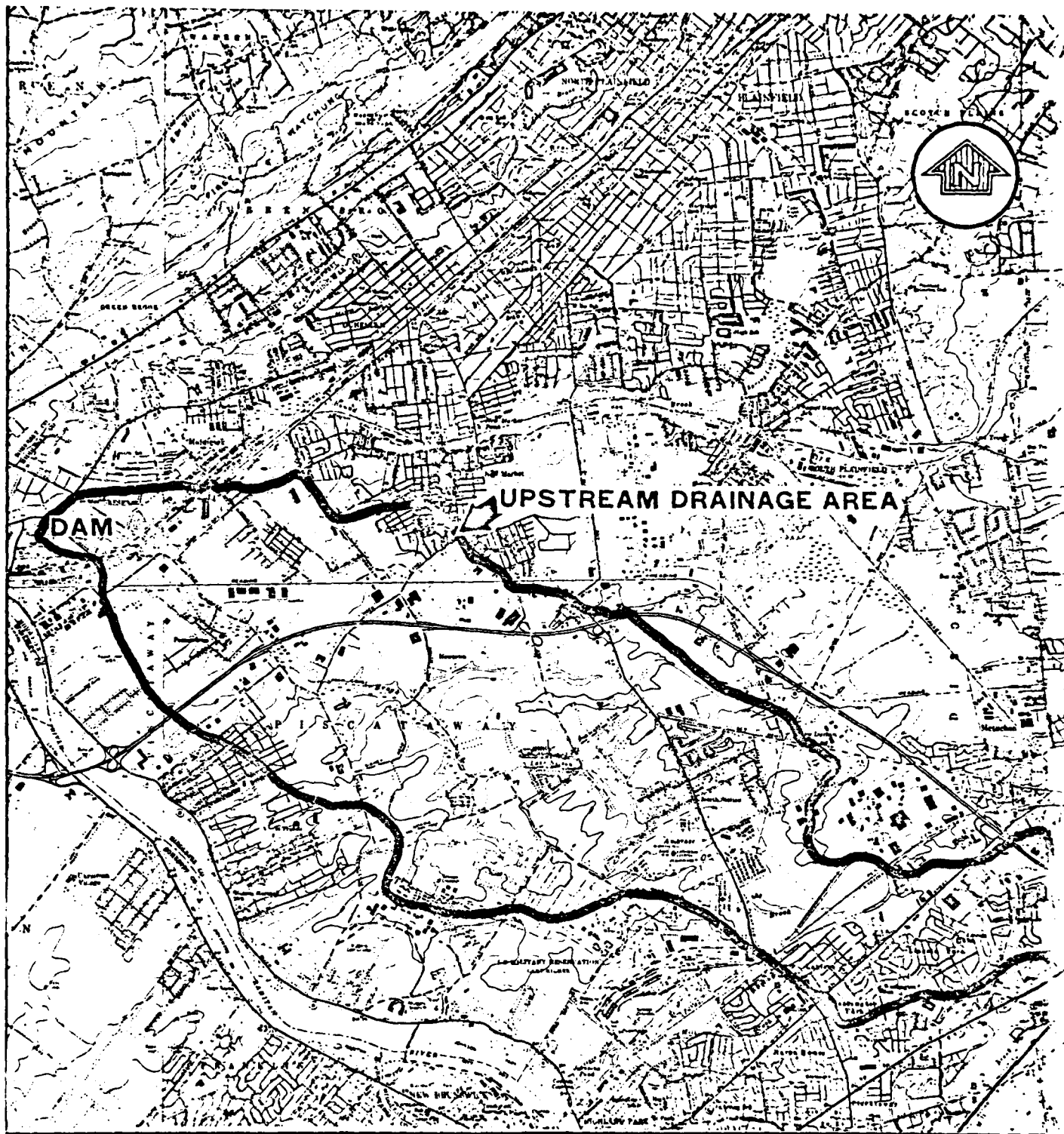
View of downstream retreat channel.

APPENDIX 3

HYDROLOGIC COMPUTATIONS

CREIGHTON LAKE DAM





**NATIONAL PROGRAM OF INSPECTION OF  
NON-FED. DAMS**

**CREIGHTON LAKE DAM  
MIDDLESEX BORO, NEW JERSEY**

**REGIONAL VICINITY MAP**

**JUNE 1981**

**DEPARTMENT OF THE ARMY  
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS  
PHILADELPHIA, PENNSYLVANIA**

Anderson-Nichols & Company, Inc.

BOSTON, MA.

SCALE IN MILES



**MAP BASED ON U.S.G.S. 7.5 MINUTE QUADRANGLE  
SHEETS. BOUND BROOK, N.J. 1955, REVISED 1970,  
PHOTO INSPECTION, 1977. PLAINFIELD, N.J. 1955,  
REVISED 1970, AND PERTH AMBOY, N.J., N.Y. 1965,  
REVISED 1976.**

JOB NO.

SQUARES  
1/4 IN. SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

## STANKOWSKI EQUATION

$$A = 13.9 \text{ sq mi}$$

$$S = \frac{88-38}{6.8} = 7.4 \text{ ft/mi}$$

$$S_t = \frac{\sim 170 \text{ acres of Ponds \& Swamps}}{8896 \text{ acres drainage area}} = .019$$

$$I = \sim 15\%$$

$$\begin{array}{r} 1.9\% \\ + 1.0 \\ \hline 2.9\% \end{array}$$

$$Q_{100} = 136 A^{0.84} S^{0.26} S_t^{-.51} I^{0.14}$$

$$136 (13.9)^{.84} (7.4)^{.26} (2.9)^{-.51} (15)^{.14} = 1772 \text{ cfs}$$

$$Q_{50} = 104 A^{0.85} S^{0.26} S_t^{-.51} I^{0.16}$$

$$= 104 (13.9)^{.85} (7.4)^{.26} (2.9)^{-.51} (15)^{.16} = 1469 \text{ cfs}$$

SPILLWAY CAPACITY FROM RATING  
CURVE CALCULATIONS = 1518 cfs

JOB NO.

SQUARES  
1/4 IN. SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

## STAGE - STORAGE DETERMINATION

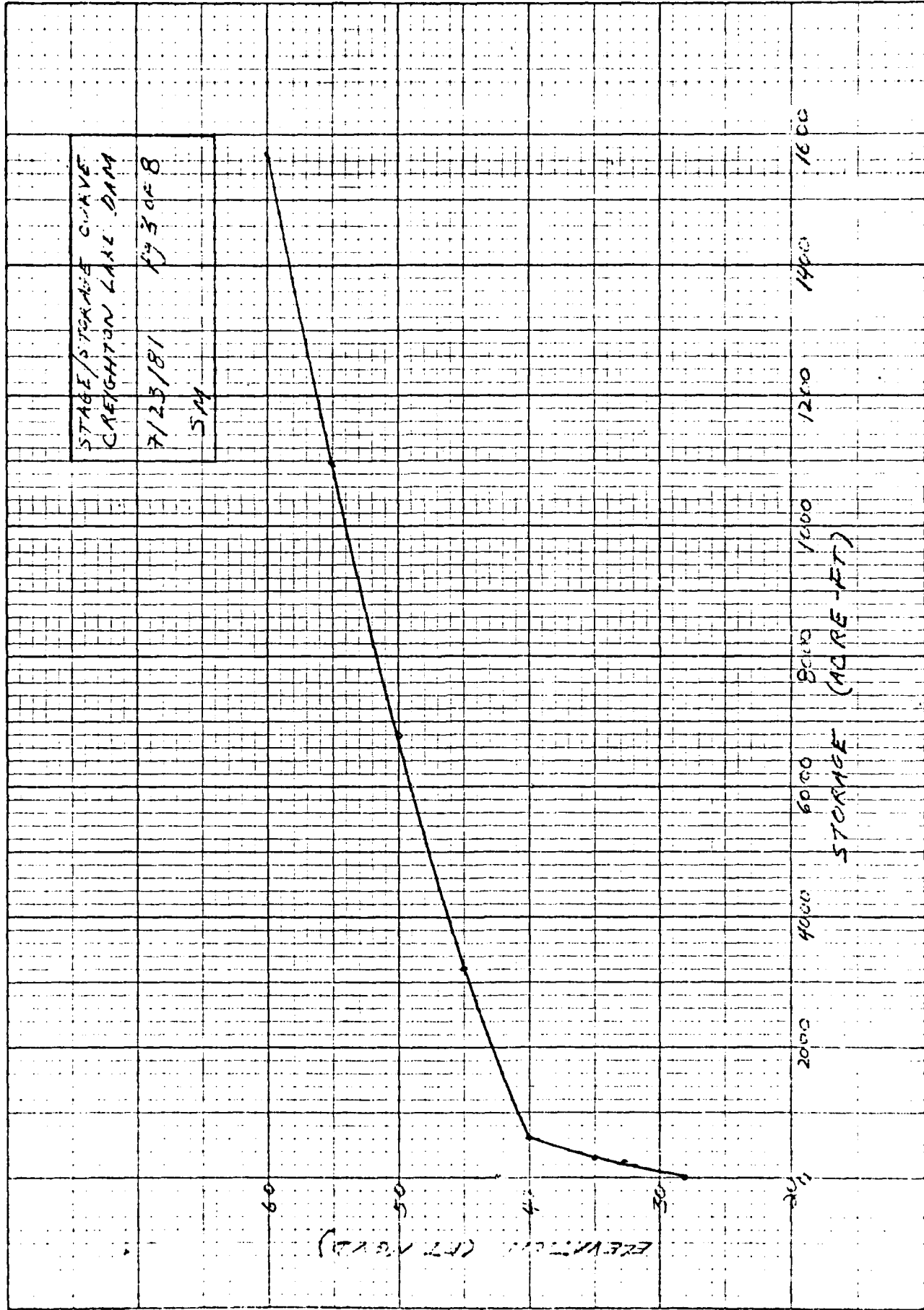
AVERAGE DEPTH OF LAKE IS 5.0'

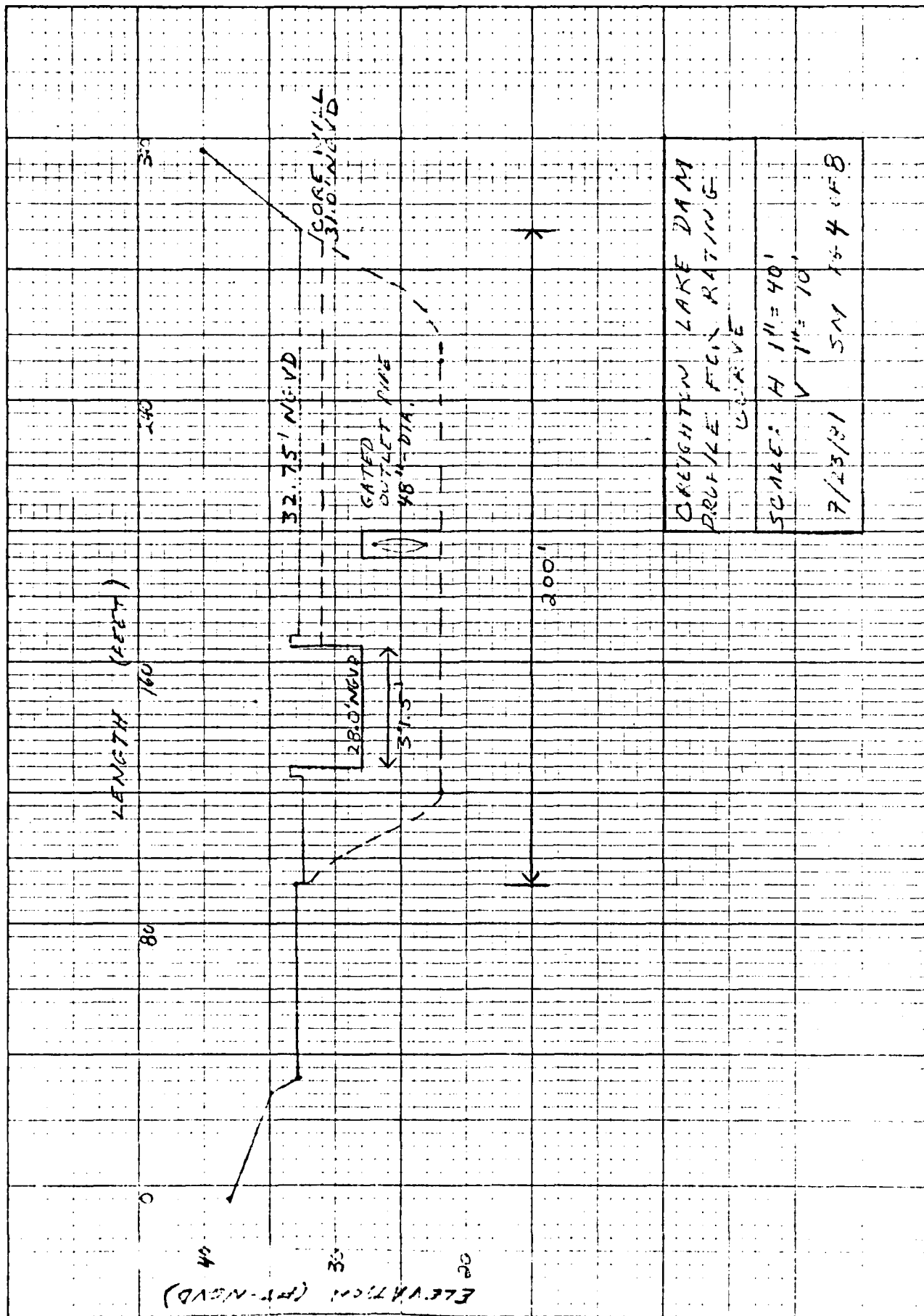
Elevation (ft. MSL)	Surface Area (acres)	Avg S.A. (acres)	$\Delta$ Storage (cu. ft.)	Cumulative Storage
28	6.4	6.4	32	32
40	89.6	4.8	576	608
60	1414.4	752.0	15,040	15648

## INPUT FOR HEC I

	<u>STAGE</u>	<u>STORAGE</u>
SPILLWAY	28	32
Top Dam	32.8	250 *
	35	350 *
	40	608
	45	3000 *
	50	6800 *
	55	11000 *
	60	15648

\* from curve





JOB NO.

SQUARES  
1/4 IN. SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

## RATING CURVE

$$Q = CLH^{3/2}$$

## 1) SPILLWAY CURVE

$$C = 3.85 \quad L = 37.5' \quad W = 3.0'$$

ogee weir

## 2) TOP OF DAM CURVE

$$C = 2.6 \quad L = 200' \quad W = 10.5'$$

(including spillway)

Elevation	Spillway		TOP OF DAM			Combined Q cfs
	head	Q cfs	head	length	Q cfs	
20 Spillway	28.0	0	0			0
21	28.8	0.8	103			103
22	29.6	1.6	292			292
23	30.4	2.4	537			537
24	31.2	3.2	826			826
25	32.0	4.0	1155			1155
26 TOP OF DAM	32.8	4.8	1518	0	161	1518
27	33.6	5.6	1913	0.8	220	2012
28	34.0	6.0	2122	1.2	220	2574
29	35.0	7.0	2674	2.2	230	4625
30	36.0	8.0	3267	3.2	240	6277
31	38.0	10.0	4563	5.2	260	12582
32	40.0	12.0	6002	7.2	280	20057



JOB NO.

SQUARES  
1/4 IN. SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

## DETERMINATION OF "C" FOR LOW-LEVEL OUTFALL

$$D = \text{DIAMETER} = 48'' = 4'$$

$$N = 0.023 \text{ CORRUGATED METAL PIPE (KING \& BRATER 6-15)}$$

$$A_p = \text{AREA OF PIPE OPENING} = 12.6 \text{ ft}^2$$

$$L_p = \text{LENGTH OF PIPE} = 21.5'$$

$$K_f = \text{FRICTION LOSS THROUGH PIPE}$$

$$K_L = \text{ENTRANCE LOSS TO PIPE} = 0.8 \text{ (K \& B 6-19)}$$

$$C_p = \text{COEFFICIENT OF DISCHARGE}$$

$$K_f = \frac{5087 N^2}{D^{4/3}} = \frac{5087 (0.023)^2}{(48)^{4/3}} = 0.015$$

$$C_p = A_p \sqrt{\frac{2g}{1 + K_L + K_f L_p}} = 12.6 \sqrt{\frac{64.4}{1 + 0.8 + 0.015 (21.5)}} = 69.4$$

$$C = \frac{C_p / A_p}{\sqrt{2g}} = 0.69$$



JOB NO.

SQUARES  
4 IN. SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

## DRAWDOWN CALCULATIONS

1. NO SIGNIFICANT INFLOW  
 2. 1 1/2 IN. FLOW LEVER OUTLET PIPE  
 3.  $Q_p = C_p H^{1/2} = 694 \text{ ft}^3/\text{hr}$   
 4.  $\Delta \text{AC-FT/day} = 1.9835 \text{ ft/day}$   
 5.  $\text{DAYS} = \Delta \text{STORAGE} / \Delta \text{AC-FT/day}$

ELEV	STORAGE AC-FT	$\Delta S$	H	$Q_p$	AVE Q	AC-FT DAY	DAYS
28	32		5	155.2			
		6			147	292	.02
27	26		4	138.8			
		5			130	258	.02
26	21		3	120.2			
		5			109	216	.02
25	16		2	98.1			
		4			84	167	.02
24	12		1	69.4			
		4			35	69	.06
23	8		0	0			

 $\Sigma = 0.14$   
 days

APPENDIX 4  
REFERENCES

CREIGHTON LAKE DAM

APPENDIX 4  
REFERENCES

CREIGHTON LAKE DAM

Chow, Ven Te, Open Channel Hydraulics, McGraw Hill Book Company, New York, 1959.

King, H.W. and E.F. Brater, Handbook of Hydraulics, McGraw Hill Book Company, New York, Fifth Edition 1963.

Lewis, J.V. and H.B. Kummel (1910-1912) Geologic Map of New Jersey, revised by H.B. Kummel, 1931, and by M.E. Johnson, 1950. New Jersey Department of Conservation of Economic Development Atlas.

Salisbury, Kummel, H.B., Peet and Whitson, Glacial Drift Map of New Jersey, 1902.

Schway, G.O., R.K. Frevert, T.W. Edmister, and K.K. Barnes, Soil and Water Conservation Engineering, The Ferguson Foundation Agricultural Engineering Series, John Wiley and Sons, Inc., New York, 1966, 683 pp.

Stankowski, Stephen J.; Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization, Special Report 38; State of New Jersey, Department of Environmental Protection, Division of Water Resources and U.S. Geological Survey; 1974.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1) Users Manual Preliminary, Davis, California, March 1981.

U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release No. 55, Washington, 1975.

U.S. Department of Commerce, Weather Bureau, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24, and 48 Hours", Hydrometeorological Report No. 33, Washington, 1977, 816 pp.

United States Department of Interior, Bureau of Reclamation, Design of Small Dams, U.S. Government Printing Office, Washington, 1977, 816 pp.

U.S. Department of Interior, Geological Survey, 7.5-Minute Series (topographic) maps, scale 1:24000, Contour Interval 10 feet: Boundbrook, New Jersey, (1955), Photorevised 1970.

Viessman, Warren, Jr., J.W. Knapp, G.L. Lewis, T.E. Harbaugh, Introduction to Hydrology, Harper and Row, Publishers, New York, Second Edition 1977, 704 pp.

END

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